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AMERICAN METEOROLOGICAL JOURNAL.

A Monthly Review of Meteorology, Medical Climatology and Geography.

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THE AMERICAN

METEOROLOGICAL JOURNAL.

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CURRENT NOTES.

THE HIGHEST POINT NORTH IS 83° 24′.—The observations taken by Lieut. Lockwood and computed by Mr. Israel, of the highest point North reached by Lieut. Greeley's party, have recently been carefully reviewed by Professor Curtis of the Signal Service. In a discussion of them before the Washington Philosophical Society, he stated that the work was highly satisfactory, giving unquestionable evidence of the latitude claimed, viz., 83° 24′. The limits of error are so small that the uncertainty is not greater than one mile.

COLD WAVES.—According to Lieut. Woodruff, in his preliminary study of Cold Waves and their progress, 15 per cent. of the cold waves traversing the continent come from the Pacific coast, while 85 per cent. originate east of the Rocky mountains, or come down the east side of them from the British Northwest Territory. The author concludes that they have their origin in the fields of ice and snow far to the north of our stations, and that they "are quite independent of the diurnal changes of temperature due to the alternation of day and night." N.

SOME THEORETICAL VALUES.—It is of interest to record results obtained by pure theory, even though we do not enter into the discussion of the theory. Thus Schlemüller, in a recent treatise on cosmic atmospheres as deduced by the principles of the dy-

namical theory of gases, finds, as an incidental result, that the mean height of the lower cloud-limit is 1,250 meters (4,101 feet). With rising temperature he thinks this distance is somewhat greater, with falling somewhat less. The author also proves that normally temperature decreases regularly with the height. Another case of deductions of meteorological interest from discussions of pure physics is to be found in Professor DeVolson Wood's article on the luminiferous ether. The article was published in the *Phil. Magazine* for Nov. 1885. In it the author incidentally studies the extent of the atmosphere. He thinks it extends indefinitely, but that the layer which moves with the earth is only about one hundred miles thick. Professor Wood looks on the ether as a very much rarefied gas, very different from those known to us, but subject entirely to gaseous considerations.

Automatic Fire-Damp Indicator.—The invention of H. G. Carleton of New York presents several novel and interesting features. One novelty is that, while of some commercial value, the inventor will not, as we learn from the *Scientific American*, take out a patent on it or place any other tax on its usefulness. The mechanical novelties are found in the employment of the changed buoyancy of the air to indicate a change in its composition and the use of a balance controlled by electro-magnetism to indicate the condition of a controlling balance which is less accessible. As to the first, a large receiver is filled with hydrogen and counterpoised on a delicate balance. A change in the constitution of the air destroys the equilibrium and causes motion of the arms of the balance. As to the second feature, another exactly similar balance, placed in the office of the mine, is so controlled that it always shows the state of the first balance located in the mine. The effects of moisture are eliminated by supplying only dry air to each balance; those of temperature by keeping the indicator-instrument in a constant temperature. The effects of changes of barometric pressure are the same on both instruments and can be eliminated by an ingenious electrical device, leaving only the differential effects for observation. The device is highly ingenious and admits of other applications.

DR. LIMUSIN (Progres Medical, Soc. de Therapeutiques) says ozone is never noticed by its odor, except when set free by means of an electric spark.

BLUE HILL METEOROLOGICAL OBSERVATORY.—We learn from a correspondent that this Observatory is now exceptionally well fitted up with instruments, especially with those suitable for mountain observations. As a sample, there are three or four patterns of anemometers and as many rainband spectroscopes. Among the instruments is a blackened mirror for the study of cloud-forms,—probably a Claude-Lorraine mirror, with which the study of clouds has an artistic effect added to its scientific attractions. On this mirror cross-lines enable the observer to note the motions.

NOTES ON THE KURO-SIWO.—In some of the best maps, as in Stieler's Atlas, the Kuro-Siwo is made to strike across the Pacific to Oregon and Washington, and to send up a narrow branch northward along the coast of British America and the Alaskan pan-handle. This branch is often omitted, and its existence seems to be doubted. As a contribution to the facts relating to it, and as a practical matter of some interest, the following may be mentioned:

The fur-seal fishing has heretofore been confined largely to Alaskan waters, especially to the Pribyloff Islands in Behring Sea. Late years it has been recognized that the seals drift up along the American coast from off Cape Flattery, passing up with a northward current. Advantage has been taken of this, in the last three or four years, to establish a seal-fishery off the Cape and Vancouver's Island. The seal-fishing is carried on in open water by Indians in canoes, brought out to the grounds by their employers in schooners. The fishing is done in March and April, and, as each schooner gets from 1,000 to 1,500 skins, it is fairly profitable. Last spring about twenty schooners were engaged,—nearly equal numbers of American and British.

The Kuro-Siwo differs much from the Gulf-stream. It is of much greater width, and of decidedly slower current. But its

chief difference is due to the configuration of the continents. The Gulf-stream flows uninterruptedly to the northeast and is finally lost in the Arctic. The Kuro-Siwo, on the other hand, is cut off from the Arctic by the western prolongation of America (making Alaska) and hence flows more easterly until it strikes the American coast and is deflected north and south. The result is that northern America is cut off from its warming influence, and so has a rigorous climate, while northwestern Europe is much benefitted by the Gulf-stream. This effect is made still more marked for the American continent by the great north and south back-bone of the Rockies, which, placed well westward, cuts off the largest part of the continent from the benefits of the prevailing westerly winds. Meantime the absence of east and west mountains leaves the United States open to cold northerly storms. Exactly the reverse happens in Europe, where the warm areas of low pressure have free access to the interior of the continent.

OPTICAL PHENOMENON.—The following description of an unusual form we take from the St. Lawrence (Dak.) *Tribune.* The date was Jan. 16, immediately before the advent of a "cold wave." "We have seen many sun dogs, halos and inverted rainbows since we have been in Dakota, but nothing to equal those of last Saturday. At sunrise there was a very bright perpendicular shaft of light passing through the sun and extending some distance above the horizon. There were also two very brilliant sun-dogs with similar shafts of light. At one time in the morning there were several bright spots on either side of the sun. There was an inverted rainbow above the sun which, with two very bright sun-dogs, remained for five or six hours. At one time the inverted rainbow was a perfect circle overhead. The day was very bright and clear and there was very little wind." The editor of this paper (Mr. C. G. Clark) is a regular meteorological observer and publishes weekly his own observations and those of the Signal Service observer at Huron.

HIGH TIDES NEAR PUGET SOUND.—They occurred from Nov.

24 to Nov. 26, 1885. They were especially remarkable in the vicinity of Whatcom and at the mouth of Fraser River. The lower part of New Westminster was flooded, and houses were washed away elsewhere. Many of the rivers there require dyking and the dykes were much injured. The *Guardian* gives the following report of its approach to New Westminster at the mouth of Fraser River: "Those who were standing on the shore last Thursday morning saw it coming, and at the distance of two miles it looked like a wall of water twelve feet high and several miles in length. It diminished in size as it approached the shore, and seemed to glide in on the land like any old-fashioned wave; but in a few minutes there was a flood; the highest flood-tide ever seen on this coast, and the Fraser river was united with Mud Bay by a pool of salt water."

REVIEW OF EUROPEAN WEATHER FOR DECEMBER.—*Barometric pressure*—From the 1st till the 6th, a series of minima travel over northern Europe, one of these with a stand of the barometer in the center of 28.50 causing heavy precipitation and severe storm over Britain, Germany and Scandinavia. On the 6th, however, a depression takes a south easterly course and is situated over Holland, high pressure advances in the N. W.; at the same time a slight depression has formed over the Gulf of Biscay, but disappears on the 9th. The last of the main minima now disappears also in the N. E. Under the influence of the high pressure in the N. W. strong Northern winds are present over Britain and Scandinavia, so that frost is now general over Britain to Southern France and Northern Italy. On the 12th, however, the maximum in the west is pressed down to France on the approach of a minimum in the N. W. Accompanied by strong to stormy winds this minimum has reached on the 14th the Northern part of Lapland, causing rain and general high temperature over the whole of Scandinavia. Severe cold now descends in a southerly direction as far as Naples; the temperature in eastern Germany has reached -13° at Cracow on the 15th. After the disappearing of another depression over northern Europe a maximum spreads over the greatest part of Europe with a barometer

stand of 30.55 at Flushing (Holland). On the 20th a low pressure appears in the N. W. and the maximum retires to Russia, frost being by this time general as far west as France and Holland. Again the main depression travels over northern Europe and another high pressure advances in the west. The weather over Central Europe is very foggy and cloudy with some rain. While the barometric pressure over Central, east and west Europe remains almost the same, very intense minima travel over north Scandinavia (Barometer at Bodö on the 24th, 28.70) where the barometer at Haporanda has fallen 1.40 inch in 24 hours. On the 28th one of these depressions on approaching in the N. W. has pressed down the maximum over Britain causing there severe storm and precipitation. Travelling easterly the center of this depression is situated on the 29th near Hernosand, on the west side of the Gulf of Bothnia where the barometer has fallen as low as 28.30. Its influence is felt as far south as France. In northern Germany and Scandinavia almost everywhere severe storm prevails. On the 30th it has sent out another minimum in a southerly direction to Italy, while the main depression is about to disappear in the N. E. On the 31st, however, a new disturbance, yet of lower importance is observed N. W. of Scotland. The temperature in northern Germany has by this time fallen as low as 12° under the influence of an almost continual high pressure. This month is remarkable for its very high mean of barometric pressure; it being in Germany, Holland, France and Britain, almost everywhere considerably above the normal.

Temperature: Germany—above the mean: 1-6, 15-20, 23-21, below the mean, 7-14, 21-22, 30-31; minimum—4° at Bamberg on the 12th, maximum 52°, at Munich on the 6th.

Ireland, Valentia—above the mean, 1-3, 12-20, 28, 30, 31, below the mean, 4-11, 21-27, 29, minimum 32°, on the 10th, maximum 53° on the 1st, 3d, 16th, 17th.

Sweden: Stockholm—above the mean, 1-5, 13-17, 19-22, 24, 25, 27-29, below the mean, 6-12, 18, 23, 26, 30, 31.

Russia, St. Petersburg—above the mean, 1-7, 14-17, 19-22, 24, 25, 28–31, below the mean 8-13, 18, 23, 26, 27, minimum—8° on the 27th, maximum 38° on the 28th and 29th.

Lapland, Haporanda—above the mean, 1-2, 5-7, 12-16, 19-22, 24, 27-28, below the mean, 3-4, 8-10, 17-18, 23, 25, 26, 27-31, minimum—20° on the 8th and 9th, maximum 37° on the 12th, 21st.

M. Buysman.

Royal Meteorological Society.—The annual general meeting of the Society was held on Wednesday evening, the 20th instant, at the Institution of Civil Engineers, Mr. R. H. Scott, F. R. S., President, in the chair.

The Secretary read the Report of the Council, which stated that the past year had been one of great activity, as the eight committees which had been appointed had met frequently and had done much for the advancement of Meteorology. The number of Fellows on the roll of the Society is 537.

The President (Mr. R. H. Scott) in his address said, "that as he had treated of Land Climatology in his previous address, he proposed to deal with Marine Climatology on the present occasion, and to take up the subject at the point where he had left it in his paper, "Remarks on the present condition of Marine Meteorology," printed in the Society's 'Quarterly Journal' for 1876. He enumerated the various investigations which had been announced to be in progress at that date, and specified the several outcomes of these inquiries which had seen the light during the ten years. The "Meteorological Charts for the Ocean District adjacent to the Cape of Good Hope," published by the Meteorological Office in 1882, was first noticed, and the methods of "weighting" observations of wind, etc., employed in that discussion were fully explained, as well as the mode of representation of barometrical results. The "Charts showing the Surface Temperature of the Atlantic, Indian, and Pacific Oceans," published in 1884, and those of barometrical pressure, now in the engineer's hands, were next noticed, and it was announced that the Meteorological Council had decided to undertake the issue of Monthly Current Charts for the entire sea-surface. The Wind Charts published by the late Lieut. Brault, of the French navy, were next described, with an expression of profound regret with which the intelligence of his premature death

in August last had been received by all meteorologists. The Wind Charts and Pressure Tables issued by the Meteorological Institute of the Netherlands, were then explained, and also the publications of the Deutsche Seewarte at Hamburg. "The Atlas of the Atlantic Ocean," &c., &c., the series of "Monthly Charts for the Atlantic and Pacific Oceans," issued by the Hydrographic Office, Washington, were then described, and the present series of "Pilot Charts," issued by the same office, were explained.

As for projected work in 1886, Mr. Scott stated that the daily maps of Atlantic weather for the year of the circumpolar expeditions were now complete and were being engraved, a process which must take several months. The German Office had undertaken the publication of daily weather maps for the same period for the South Atlantic. The Meteorological Office had also taken up the Marine Meteorology of the Red Sea. The Dutch Institute had announced its intention to publish an atlas for the Indian Ocean.

In conclusion, Mr. Scott stated that there still existed a lamentable want of data for the Pacific Ocean, but that, thanks to the energy of the Canadian Government in opening up their new Pacific Railroad, it was to be hoped that every year would bring a greater amount of traffic to British ports on the Pacific coast, and therefore a greater number of observations to the Meteorological Office, while from the existing trade to San Francisco a mass of materials was quickly accumulating for certain routes, at least, over the vast area of the Pacific.

The following gentlemen were elected the officers and Council for the ensuing year:

President: William Ellis, F. R. A. S. *Vice-Presidents:* George Chatterton, M. A., M. Inst. C. E.; Edward Mawley, F. R. H. S.; George Mathews Whipple, B. Sc., F. R. A. S.; Charles Theodore Williams, M. A., M. D., F. R. C. P. *Treasurer:* Henry Perigal, F. R. A. S., F. R. M. S. *Trustees:* Hon. Francis Albert Rollo Russell, M. A.; Stephen William Silver, F. R. G. S. *Secretaries:* George James Symons, F. R. S.; John William Tripe, M. D., M. R. C. P. Ed. *Foreign Secretary:* Robert

Henry Scott, M. A., F. R. S., F. G. S. *Council:* Edmund Douglas Archibald, M. A.; William Morris Beaufort, F. R. A. S., F. R. G. S.; Arthur Brewin, Frederick William Cory, M. R. C. S.; Henry Storks Eaton, M. A.; Charles Harding, Richard Inwards, F. R. A. S.; Baldwin Latham, M. Inst. C. E., F. G. S.; John Knox Laughton, M. A., F. R. G. S.; William Marcet, M. D., F. R. S., F. C. S.; Cuthbert Edgar Peek, M. A., F. R. A. S., F. R. G. S.; Capt. Henry Toynbee, F. R. A. S.

Atmospheric Electricity.—The result of the competition for the prize offered by the French Academy for the best essay on "the origin of atmospheric electricity, and the causes of the great development of electrical phenomena in thunder clouds" has just been made known. The Bordin prize of a gold medal worth 3,000 francs, was offered first in 1882, and as it was not awarded, re-offered in 1885. There were fourteen memoirs presented, of which 12 were in MS., (five in French, four in German, and three in English). Two printed monographs were presented. The committee were M. M. Fizeau, Cornu, Jamin, Mascart and Becquerel. The report of the committee, following, is translated from the "Comptes Rendus" No. 25, December 21, 1885, pp. 1135, et. seq. Many of the essays contained full and valuable studies of the question. The majority of the essayists touch generally on the different hypotheses that have been advanced from time to time. The first half of the question received more attention than the latter half. Of the fourteen essays presented, the committee comment on five.

"The essay numbered 13, entitled "Sept etudes sur electricite, etc.," advances as the prime factor in the production of the electricity of the air, the electrification of the ice and other particles in the air, by friction against damp air. His studies are interesting, but his explanations are not sufficiently complete."

"The author of memoir No. 6, (in French) attributes the origin of atmospheric electricity to the chemical action of the sea on the land, the vapor and spray, being positively electrified; also, the friction of wind against earth surfaces, and possibly the friction of ice crystals in suspension in the air. This electricity

accumulates in the high regions of the air, as where cirrus clouds are found, and this is the reservoir from which the clouds are supplied. The author has made some new experiments with a view to demonstrate the truth of his theory with apparatus that appears to be well devised and constructed; but experiments of this nature demand repetition and exactness before conclusions can be drawn from them."

"The author of memoir, No. 7, (in German) starts with the classic experiment of Armstrong, with steam, and claims that the friction of masses of damp air, and snow, hail and dust, originate electricity, and this is further developed by the movements of the air in storm areas. In short, the electrical phenomena of the air have uniformly as their originating cause, mechanical action. His essay is interesting, but the considerations he makes most of do not appear to the committee to be justified by experiment."

"The author of memoir 11 (this memoir came from the United States) gives experiments which prove that conclusions are uncertain. He shows in detail the relation already found to exist, between the frequency of the thunder storms on the island of Mauritius and the distribution of areas of "high" and "low" pressure, and shows that a like relation is found in the United States, and in Belgium. This author refuses to draw conclusions and allows as the only admission, the fact that atmospheric electricity resides principally in the higher regions of the atmosphere. The memoir is the work of a trained observer and one well abreast of the workings of experimental physics."

"Memoir, No. 12, (in French) is a long and interesting work beginning with a complete historical account of the different hypotheses. The author has also experimented with an electrometer of his own invention, using chiefly the conducting flame method. He discusses two main points. 1st: Whether the air is electrified 'per se;' and 2d: Variation of potential with height free from and under the influence of cloud masses. He is unable to answer definitely the first of these, but with regard to the second gives numerical values, and this under the different conditions of cloudiness. He rejects the different theories proposed except that of Peltier, based on experiments originally made by

Erman, and which lead to the belief that the earth has an original electrification, which inductively affects the atmosphere. This hypothesis while admitted by many physicists, still fails to explain the diverse conditions under which this accumulation of electricity occurs. This work well deserves honorable mention."

"The printed paper of Mr. Edlund, Professor of Physics in the Royal Academy of Sweden, especially attracted the attention of the committee, because of the ingenuity and originality of the views advanced. The theory of Mr. Edlund is based on his experiments in electromagnetic induction, particularly that which he calls "unipolar induction." If a hollow cylindrical conductor surround one pole of a permanent magnet whose axis is in the same direction as that of the cylinder, the other pole being at an infinite distance, when the cylinder is rotated there is produced in the direction of a generatrix of the cylinder, a difference of potential, dependent upon the rotation, remaining the same whether the magnet be fixed or move with the cylinder. The earth and the atmosphere constantly under the influence of terrestrial magnetism, are assumed to correspond with the outer cylindrical conductor. The air acquires a positive charge, which is conveyed to its upper regions, whence it streams towards the poles. While the air at the earth's surface is not a conductor, the air in high regions, owing to the diminished pressure conducts well. The author explains the aurora on this assumption, and argues that the variation of auroral display with latitude can be thus explained. The resistance to the neutralization of these electricities is greatest at the equatorial regions, diminishing at the poles. Edlund gives the following values, as deduced from his theory for the variation of magnetic potential with altitude in our latitudes. For one metre an increase equal to 0.023 volt.; for 100 metres, from 2 to 3 volts. This value is much below that obtained by experiment, in free air under a clear sky, but Edlund supposes that this is sufficient to produce results observed. The hypothesis advanced by Professor Edlund is ingenious and developed with ability, but in the present state of our knowledge, it is unwise to attempt explanations of this nature. The committee making this allowance, wish to testify the interest they

have taken in the work of this savant, and as a mark of their appreciation propose that the Academy award him the prize.

A. M.

OZONE-TESTS. *Practice vs. Theory.*—In testing for ozone, the investigator is confronted with many phenomena that he cannot understand nor account for upon our present knowledge of atmospheric ozone; but to the enthusiastic investigator these unexplained anomalies serve only to nerve him to greater perseverance in his efforts to ascertain the true nature of this constituent of the atmosphere.

The discouraging criticism which has attended every species of investigation since man first attempted to ascertain the nature of physical phenomena, has tended, on the one hand, to delay the progress of investigation by scaring off the timid and doubtful, and on the other hand, has resulted in compelling a more careful progress on the part of those who will not be discouraged in their efforts to ascertain new facts.

All are aware of the almost violent opposition which has attended the progress of M. Pasteur's great work, and it is to the fortunate circumstance that his span of life has been extended, that the present géneration is indebted for the benefits it is deriving from the successful fruition of his labors. Had he not tried to fulfill his mission, the great truths which he has demonstrated would doubtless have lain dormant for half a century longer.

The investigation of atmospheric ozone has not escaped this scrutiny of the methods attending it, and it is perhaps fortunate that it is so; as otherwise, observers would doubtless have been led into many errors that a timely criticism would enable them to avoid. On the other hand, it is believed that many of the objections to the tests at present employed, growing out of laboratory experiment, will have been demonstrated to be groundless upon further experiment and observation in nature.

It is believed that our actual knowledge of ozone and its true cause is very limited, and that its importance as an oxydizing agent, in relation to our physical welfare, is not fully appre-

ciated. Nevertheless, the imperfections of our present methods of observation are apparent. They are, at best, but approximate and relative; but we can at least make a very fair comparison between different latitudes and localities, as well as between different periods of time at the same place; and will thus be enabled to study, with a tolerable degree of success, the correlation between it and the more prevalent diseases. I have traced an intimate relation between it and the malarial diseases—the higher results in ozone being followed during the succeeding week by a diminished mortality from this cause, but have in every such attempt been met with some break in the chain of evidence that could not be ignored, nor accounted for upon any known cause. I nevertheless fully believe that such a relation does exist, but that we have not sufficient'y studied the subject to arrive at all facts in the inquiry.

I think the evidence afforded by the earlier investigators in Europe, as well as by those at present engaged in both Europe and America as to the relations of this substance to disease, should offer sufficient incentive to observers to continued efforts in this direction.

Meanwhile, it is hoped that some inventive genius will have devised some mechanical apparatus that will meet the requirements, both for accuracy and convenience of management.

I. H. S.

New Orleans, January 28.

FOREIGN STUDIES OF THUNDER-STORMS.

FRON ON THUNDER-STORMS IN FRANCE.

The systematic study of thunder-storms in France was undertaken in 1865, when through the encouragement and assistance received from the minister of public instruction and the departmental prefects, a great force of observers was turned to the work. A certain number of instruments was provided at government expense for the normal primary schools; and the general records included 1°, time of beginning and ending of storm, meaning thereby the time of first and last thunder; 2°, direction

of storm and of clouds; 3°, direction and force of wind; 4°, notes on lightning and thunder; 5°, time of rain and hail; 6°, reports of damage by the storms. Directions are recorded to octants, and intensities are all given on a scale of six. Temperature is not observed. In the first season's work, as many as 800 reports were sometimes received in a single day; the mass of data soon became so large that departmental commissions were formed, everyone to reduce its own observations and to pay the small cost that the work involved. The reports are on one side of a quarto sheet, with instructions on half of the other; they are folded and sent unsealed without envelope, post free, to the departmental prefect. As an encouragement to the volunteer observers, 12,515 storm maps were distributed among them during the first year of the investigation. In the later reports there is mention of silver and bronze medals that were given to the best observers. The reports from the departments were edited at first by the Imperial Observatory at Paris and published in handsome form by the minister of public instruction; they were then issued as large folios, with prefaces by Le Verrier, the first one bearing the title "*Atlas des orages de l'année, 1865*;" the following "*Atlas météorologique de l'observatoire imperial,*" from 1866 to 1876, with the significant change to "*l'observatoire de Paris,*" in the later volumes. In 1878 the "Bureau central meteorologique" was established, with Mascart as director, and under his charge the "*Etudes des orages en France*" were issued, with other memoirs, in large quarto volumes of *Annales*, beginning with the storms of 1876.* M. Fron has from the beginning in 1865 had charge of the general descriptions that precede the local accounts in each volume; his reports are in great part simply descriptive, recounting the occurrence of storms in time and and place with few summaries and still fewer theoretical generalizations. There seems to be no statement of what may be called the mechanism of thunder-storms. It was early announced that the storms came from the ocean, or in other words, that

* With a few exceptions, the whole series is to be found in the Library of the Harvard College Observatory, where I have had opportunity of making these notes.

their motion was as a rule from southwest to northeast; in many cases this direction was held with an even velocity over the inequalities of hill and valley; at other times the storms turned aside from the central plateau or from the mountains on the south and northeast. In the volume for 1867 M. Fron remarks that regions of high pressure have few and small storms; cyclonic storms (*Bourrasques*) are nearly always accompanied by thunder-storms in summer, but in winter only when violent; they seem to be surrounded by a stormy ring at a certain distance from the centre in which thunder-storms are most common, so that one observer may be twice visited by thunder-storms during the passage of a single area of low pressure (page A 12). A more extended series of general conclusions is given in the volume for 1878 (page A 36), based on all the work up to 1877, and is here abstracted.

Thunder-storms are always connected with a more or less considerable barometric "depression." In winter, lightning and thunder are often reported at a low temperature during a violent tempest in whose center the pressure is only 712 mm., while it rises to 770 mm. in the surrounding ring of high pressure; in summer, the depressions are faint, but June and July have the most thunder-storms. In both seasons the relations of thunder-storms to depressions is the same; the storms occur in the "dangerous" (right hand ?) half of the depression, between the center and border, and move in accordance with the cyclonic winds that rotate around the center. The centers of depressions reach western Europe in four ways; 1°, across higher latitudes, when France has south to west winds (*e. g.*, September 4–12, October 9–16, 1875); 2°, across the Mediterranean, south of France, when the winds coming from the south and east carry storms (May 15–19, 1876); 3°, across France itself, when storms are rare north of the track but common to the south of it (April 22–26, 1876); 4°, the storms may be the reaction of rotations (*contre-coup de mouvements tournants*) stationed on the Atlantic west of France for several days, maintaining a very high temperature and humidity on land; storms are then numerous and large, and recur on several successive days (August 13–21, 1876). The

mean velocity of thunder-storms is ten to twelve leagues (a French league=$2\frac{3}{4}$ miles) an hour. Storms are seldom isolated; they generally occur in groups, during a 'stormy period.' In winter the cyclones (bourrasques, depressions) occur every two or three days in marked intensity; the thunder-storms occur to the south of them. In summer the cyclonic storms are weaker but more numerous; it often happens that several follow one another on a single day. In such case, the thunder-storms belonging to one low pressure center are separated from those belonging to adjacent centers by a (faint ?) barometric maximum. Thunder-storms may occur twice during the passage of a single depression, once while the pressure is decreasing, again while it is increasing. Where they appear, the isobars are inflected.

The fine charts accompanying these reports contain much material for further study. In the earlier volumes, the isobars for 7 A. M. were drawn on the chart that detailed the storms for all hours of the day. Later, five small maps are added, giving isobars for five millimeters, with the winds and weather every three hours from 9 A. M. to 9 P. M. The storms themselves are shown by isochronal lines, for hours and sometimes for half hours, with arrows indicating the line of advance. Lightning strokes, light and heavy hail and rain are indicated by appropriate signs. There are also departmental charts on a much larger scale, sometimes showing the storm wind, or the paths of several years' storms in which the SW—NE are much the most common. But as already noted, general statements are seldom made in regard to the mechanism of storms.

Fron has written: "Des orages et de leurs rapports avec les mouvements generaux de l'atmosphere;" Paris, Ann. Soc. mét., XV, 1867, 95-161. I have not been able to consult this.

FERRARI ON THUNDER-STORMS IN ITALY.*

Systematic observations of thunder-storms in Italy before in 1877, by Schiaparelli, and published by the royal observatory of Brera at Milan. In 1880, the plan of work was much extended

*See also this Journal, January, 1885, 379.

by the Central Meteorological Office. Since then the reductions have been in charge of Dr. Ciro Ferrari, who has published extended memoirs in the "*Annali dell, ufficio centrale di Meteorologia,*" (ser. ii, vols. iii and v) entitled "*Osservazioni dei temporali e relativo studio,*" (259 and 327 p., 40 and 36 plates) in which the results of thunder-storm observations in Italy in 1880 and 1881 are presented. An abstract of the latter memoir is given by Ferrari himself in the *Meteorologische Zeitschrift* (23 p.,) for October last, a brief review of which is here presented.

Rain records were obtained from 356 stations, and storm records from many more; so that 650 separate, individual storms were determined by nearly 11,000 observations. The progress of the storm is shown by isochronal lines for every hour, giving position of the most violent part of the storm—the maximum phase—for these times; it is admitted that the curves thus drawn may be somewhat ideal, but their general accordance shows that they represent a truth. The observations on which these results are based are not very unlike those prescribed in other countries, except that temperature records are requested in addition to the other elements of the storm. Brief accounts of severe storms serve to illustrate the method of study.

The generalizations based on all the observations for 1881 contain much of value for comparison with similar work in progress in this country. Most of the storms (70 per cent. in northern Italy, 75 per cent. in middle and southern Italy) come from the northwest quadrant of the horizon; this confirms the results of 1880. The velocity of progression is 33.6 kilom. an hour for northern Italy; 36.4 for the whole peninsula. The faster the progress, the more violent the wind and the electrical phenomena that accompany the storm; thus destructive hail-storms are found among those that advance rapidly; also, the faster the progress, the shorter the duration. Of the 650 storms, 324 were too small, or at least observed at too few stations, to permit of a determination of their direction and velocity of progress; the remaining 326 are divided into large storms and local storms; the latter sometimes occur alone, but are most frequent on days that produce large storms as well. The local

storms sometimes seem to be intermittent (*temporali a salti*); they are in nearly all cases of weaker development than the large storms, their electric display, wind, rain and hail all being of low grade; they may occupy only ten square myriametres (a surface about twenty miles on a side).

The storms also vary as regards the area over which they spread; some cover a long narrow strip of country as they advance, others widen from the point or area of origin so as to cover a surface shaped like a circular sector, whose middle line shows the storm's advance. At any single moment the storm exists as a narrow band, straight, curved or irregular, with a single or several points of greater intensity than the rest; during the advance the successive attitudes of the band are about parallel. No definite classification can be made, as the varieties all grade into one another.

The relation of thunder-storms to barometric pressure requires numerous and accurate observations for its discovery. Nothing definite appears on charts with isobars every five, or even every two millimetres; but when isobars are drawn for every millimetre, it appears that the storms occur on the after side of a small, faint area of low pressure; and that the pressure rises as the maximum phase of the storm approaches. The low pressure area is more marked for hail-storms; it is generally smaller than the storm area itself; when it enlarges, as often happens in spring and autumn, the storm changes to an ordinary rain-storm. Sometimes the storms form at the end of a U-shaped "sack" or embayment on the side of a large area of low pressure. The following table exhibits the relation of thunder-storms and ordinary rain in Italy to the larger areas of high and low pressure.

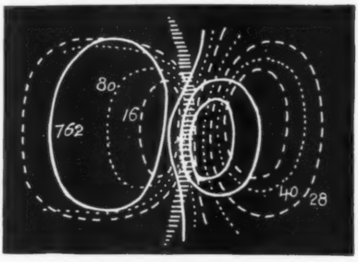
In this table, 'near' means six to 500 miles; 'far,' over 500 miles. It is further stated that 29% of all thunderstorms occur in the center of large areas of low pressure; 51% more or less distant, but within the low pressure area, and of these, twenty-one are in the front and thirty in the rear of the center; and 19% are in a region of uniform pressure. When a large storm is near a low pressure center, the storm band extends along a radius from the center.

	All Italy.		N. Italy.	
	Thunder Storms.	Rains.	Storms.	Rains.
1. In the center of high pressure area	0.0	0.3	0.0	0.6
2. Near by such a center	0.3	1.4	0.4	1.5
3. Far from such a center	0.5	0.5	2.0	2.0
4. Between high pressure on the NW to NE and low pressure on S to ESE	0.6	2.2	0.5	3.6
5. In center of a low pressure area	13.7	60.1	21.0	70.0
6. Near by such a center	8.2	36.1	10.5	41.9
7. Far from such a center	4.1	20.4	12.6	36.9
8. Very far from the same	0.4	2.0	0.0	2.5
9. In a region of uniform pressure	3.7	7.8	5.7	12.9
10. In an isobaric 'sack,' opening NE to E.S.E.	.....	.....	13.3	27.5

The relation between temperature and thunder-storms is clearly made out; the storm-band shows between an area of high temperature in front of it and low temperature in the rear. The most rapid change of temperature is in the storm-band; the thermometric difference between the warm and cold areas averages 11.7° F.; for small storms, it is less than 7°, and in winter, still lower; while for hail storms it is probably above 20°. After the storm passes, the temperature rises again.

The relative humidity falls to 40% in front of the storm, and rises to 80% within it.

The accompanying diagram represents these relations graphically; the storm band being in the middle, the isobars are full lines, the isotherms, dotted, and the lines of equal relative



humidity, broken. The priority of pointing out this relation between thunder-storms and isobars on the basis of numerous and accurate observations belongs to Ferrari.

When lines of equal rainfall are drawn, they generally form ellipses, with the major axes parallel to the storm's advance. Rain occurs in practically all cases; it is less in summer than in winter; and while rain falls in the valleys, snow falls on the mountains.

Hail was noted in 344 out of the 650 storms; it falls along narrow strips of country parallel to the storms advance. As the storms generally come from WNW, with wind from the same quarter, it is recommended that plants and vines, that would be injured by hail, be set out in belts in the same direction.

The electric display appears most energetic in the warmer months; and in a single storm, it is frequently concentrated in several separate areas in which lightning strokes are recorded.

A tolerably well marked tendency to repetition of storms in a single region was noticed; especially on days when few storms occurred. Heat lightning could be in nearly all cases referred to a distant storm.

Ferrari has also written "Ueber Vertheilung des Luft druckes und der Temperatur bei Gewittern." *Zei schrift f. Meteorol.*, 1883, 426–427.

Ueber die Krümmung der Barometer-Kurve während des Gewitters. *Das Wetter*, i, 1884, 135–137.

Sulla Dinamica dei temporali. *Trans. R. Accad. d. Lincei*, Sev. 3 a, VIII, 1884, 346-348.

While this paper is in proof, I have received copies of Ferrari's original memoirs, above referred to; in detail of statistical discussion and of graphic illustration, they are more elaborate than those of any other country that I have examined.

VON BEZOLD ON THUNDERSTORMS IN BAVARIA.

Professor Wilhelm von Bezold, lately appointed to the chair of meteorology in the University of Berlin, devoted much attention to the study of local thunder-storms while in his former position as chief of the Bavarian weather service in connection with Dr. Lang. The results are published in several volumes entitled "Beobachtungen der Meteorologischen Stationen im Königreich Bayern," since 1880; and an abstract of them is

given by himself in the "Elektrotechnischen Zeitschrift," March, 1883, which is republished in the Austrian Meteorological Journal for June of that year: from the latter, I take these brief notes.

The large amount of material accumulated from Wurtemberg as well as from Bavaria is shown in the table on next page.

The reports were made on cards that were carried post free through the mails, and gave simply the time of first and last thunder, rain and hail, the direction of the storm's appearance and disappearance, and the direction and strength of the wind before and during the storm. The omission of temperature observations and the absence of any sufficient correlation of the several subjects of record, which characterize nearly all European investigations of thunder-storms seems to me greatly to diminish their value.

	Stations.		Reports.	
	Bav.	Wurtt.	Bav.	Wurtt.
1879	279	—	3571	—
1880	234	62	5741	303
1881	249	59	6630	1174
1882	252	61	4162	893

The storms were charted by 'isobrontal' lines, that joined places having the first thunder at the same time, which are said to give a fine picture of a storm's progress. The conclusions drawn are briefly stated as follows:

1. When thunderstorms are not part of violent cyclones, which are rare in Bavaria, they appear at times of quiet air, with considerable local differences of temperature, and accompanying barometric depressions. On maps having the pressure shown from five to five millimeters, the areas of low pressure are but faintly indicated by curves in the isobars; with more detailed study, they appear in greater distinctness and are generally seen to be extensions of larger low pressure areas, with gradients so faint that they cause no noticeable winds.

The progress of the storm is independent of the local surface winds, but follows the higher winds in their motion about the larger centers of low pressure. Hence, the storms advance to

east when they arise to south of a pronounced center of low pressure; to the west, when they appear to the north of these centers, but this case is relatively infrequent. An exceptional number of east to west storms occurred in 1880, when the areas of low pressure were also more numerous than usual. When the storms are examined in detail, the winds about the small areas of faint low pressure are found to obey Buys-Ballot's law—that is, they flow obliquely to the right down the gradients—and the clouds also move in various directions. Storms are especially frequent in the 'saddle of high pressure' between two adjacent low pressure areas.

2. When lines are drawn so as to include the whole district over which thunder is heard at a given time, the area thus occupied is found to be a long, narrow band, at right angles to the storm path. Storms are frequently observed that stretch from the northern limits of Bavaria to the Alps, about 200 miles, while their breadth (determined by audible thunder) is at the highest fifty miles, generally about twenty-five miles, and often much less. In such cases, the entire length of the storm band is not measured.

3. There are certain places which are peculiarly favorable to the development of storms, which v. Bezold calls *Gewitterherde.* (Storm focus is not a satisfactory translation of the term, as this implies a point of concentration rather than of departure; storm centre already has another meaning; perhaps *storm nest* may serve in this meaning). Such are the swampy low lands between the large lakes and the Alps, and the western slope of the Böhmerwald: but the largest Bavarian storms originate between the Rhine and the Schwarzwald.

4. In cases where storms begin within the field of observation, the electric discharges appear almost simultaneously over a long line; it is probable in such cases that the first discharge excites or gives opportunity for the others.

5. Heat-lightning is recorded from storms 150 to 170 miles away.

6. Storms are most frequent in Bavaria at three to four o'clock in the afternoon; a second well-determined, though weaker max-

imum appears from one to three o'clock in the night. In Wurtemberg, the time is about an hour earlier. It is concluded that the time of maximum frequency must vary in different districts, according to their distance from the nest where the greatest number of storms is produced.

The Austrian Meteorological Journal for August of the same year contains a second article by von Bezold, "On the distribution of pressure and temperature in large thunderstorms," (7 p. and one pl.). Special attention was given to the pressure and temperature (both reduced to sea level). During extended storms in 1882, synchronous maps being prepared for 8 A. M., 2 and 8 P. M., and the isobars being drawn for every millimeter, an intimate connection was discovered among the isobars, isotherms and isobronts. Just in front of the storm band, the pressure suddenly increases and the temperature suddenly falls; so that the front margin of the storm separates a region of lower pressure and higher temperature from one of higher pressure and lower temperature, the latter being within or behind the storm. When the isobars stand north and south, the wind that immediately precedes the storm blows square across them (generally therefore from west to east) and thus departs from Buys-Ballot's law. This exception is thought to be due to the rectilinear instead of concentric altitude of the isobars.

The last volume of the Bavarian observations, for 1884, continues the study of thunderstorms on the same plan as in previous years. The following brief extracts are taken from it.

The storms of 1879–1882 were much larger and more regular than those of 1883–1884; this frequency coincides with a rise of temperatuie. Progression from east to west, when the associated area of low pressure is to the south, is confirmed, and the several small storms of June 14, 1884, are charted in illustration of this rule. Many additional statistical details are given.

W. M. DAVIS.

HARVARD COLLEGE, CAMBRIDGE,
January, 1886.

THE MOUNTAIN METEOROLOGICAL STATIONS OF EUROPE.

A. LAWRENCE ROTCH, S. B.,
Member of the German Meteorological Society and Fellow of the Royal (British) Meteorological Society.

AUSTRIA AND SWITZERLAND.

The Hoch Obir.

This mountain lies in the Austrian province of Carinthia in Lat. 46° 30′ N., and Lon. 14° 27′ E. of Greenwich and rises high above the Obir group of mountains, from which, the only connection being a low "col," its limestone mass is quite isolated.

Meteorological Station.—This station is the highest in Austria, the anemometer on the summit of the Hoch Obir having an altitude of 2,148 m. above the sea. The house used by the observer, in and about which are placed the other instruments stands 100 m. lower, protected by the peak except on the South. The observations date from 1846 and were made regularly by the mine overseer till the mines were abandoned in 1875. The observations are wanting for 1876 and 1877, but in August, 1878, they were recommenced. The stone house which the miners had used for forty years was rebuilt and a regular observer appointed by the Austrian Meteorological Office at a salary of 30 fl. a month. In summer he also acts as innkeeper, though on account of the primitive accommodation and the difficulty of access, the Obir is only visited by about a hundred strangers during the summer. The annual cost of maintaining the station is about 900 fl. A barometer was provided in 1879, and through the efforts of Dr. Hann, registering instruments have since been added, so that it is now a station of the first order and there seems little doubt that it was, as Dr. Pernter claims, the pioneer of the first class mountain stations, excepting perhaps those in France. At any rate, no mountain station has had its observations so fully and so ably discussed as has the Obir.

The standard barometer with a fixed cistern and a capacity correction to compensate for the change of zero was made by Kappeller of Vienna. There is a Hottinger barograph registering according to the following principle. A number of aneroid

boxes are connected with a lever moving in a horizontal plane. Each hour a pawl resting on a ratchet wheel is dropped and striking the lever registers the height of the barometer by a prick on a paper band drawn beneath by clockwork. The normal barometric height is indicated by a fixed needle which each hour is made to puncture the papeı as above. The wet and dry bulb thermometers are exposed at a height of 0.90 m. from the ground, in a cylindrical zinc screen, which is again enclosed in a wooden cage on the South side of the building. On the North, the building is partly embedded in a bank, which precludes the placing of the thermometers on this side. A "control" thermometer is placed in a zinc screen on the East wall of a wooden outbuilding. A six maximum and minimum thermometer by Casella of London, in the first described shelter, is read at 9 P. M., and a Hottinger hair hygrometer with a means of testing and adjusting for complete saturation is read at each observation in connection with the humidity obtained from the psychrometer. Ozone tests are made with Dr. Lender's paper, exposed in the screen during the day time, and the discoloration is estimated on a scale of 11. A Hottinger thermograph records the variations of air temperature by the contraction or expansion of a brass spiral in the screen which registers its motion inside every half hour upon a moving band of paper, in a similar manner as in the barograph. A detailed description of these two instruments will be found in the Austrian *Zeitschrift für Meteorologie* for July, 1881. It may be remarked that although the Hottinger barograph and thermograph have been extensively used, especially in Austria and Switzerland, they are now being superseded by the simpler and cheaper French instruments of Richard, which give, moreover, continuous registration. The barograph of Hottinger costs 450 francs, that of Richard but 125 francs.

The rain gauge is 0.50 m. high, has a circular receiving surface of 1-20 sq. m., and from the collecting vessel below, the water is drawn off through a cock into a glass graduated to 0.1 mim. There is also a snow gauge consisting of a cylinder having the same area, both gauges being placed 1.44 m. above the ground West of the station and read daily at 7 A. M. A Campbell-Stokes

sunshine recorder stands on a post to the South. This instrument, which is well known in England, consists of a glass sphere placed in a concentric frame, which holds a strip of cardboard that is changed daily. The sun's rays are focussed upon the strip, burning it whenever the sun shines, and by the sun's apparent motion traverse successively the hours inscribed upon the cardboard. The number of hours of sunshine recorded divided by the possible hours of sunshine gives the percentage of sunshine. The direction of the wind is obtained from a vane elevated on a pole, and its force from a Wild pendulum pressure-plate, the scale being estimated up to 7. On the summit of the mountain is the anemograph on the Beckley-Casella system, erected in August, 1883, by the Austrian Meteorological Society, at the cost of the Alpine Club. It is unfortunate that the instrument should not have been erected upon the actual summit. In point of fact, the base is about 3 m. below the highest point, with which the Robinson cups are barely on a level, so that the recorded velocities of the S. W. winds must be too small. An insecure foundation on the apex is said to be the reason for this seeming error. The velocity is obtained by a set of Robinson cups which by means of gearing turn two wheels, one bearing the type figures 0 to 10, representing kilometers, with subdivisions for the halves, which are impressed on a band of paper that the wheels draw between them. Each hour a hammer dropped by clockwork punctures the paper band, and at the same time imprints the direction of the wind on it by an arrow type below, which is turned by vanes situated below the cups. The paper band is changed weekly. The anemograph is connected with the house by a wire 1–2 kil. long, so that in winter the clock may be kept there and the hammer dropped by an electric current. Nevertheless, the action of the anemograph in winter is very uncertain and its action is often stopped by the frostwork.

The complete set of observations made at 7 A. M., 2 and 9 P. M., is as follows: Barometer, corrected for temperature only; temperature, relative humidity and force of vapor; amount of cloud on a scale of 10 and direction moving; wind direction to 16 points and force; kind and amount of precipitation (recorded at 7 A. M. only); ozone.

In 1881 a telephone line, 14 kil. long from the summit of the Obir to Eisenkappel at its foot was built by the Austrian Alpine Club at a cost of 900 fl., by which the morning observations since 1883 have been daily telephoned in the international cipher to Eisenkappel, and thence telegraphed to Vienna in time to be used in the Daily Weather Bulletin, issued by the Central Office. In winter, owing to the storms, it is necessary to take the wire from the poles and lay it on the snow, where it is found to work well. The reduction of the observations and the calculations of the five day means are made by the observer and entered on a monthly form which goes to the Central Office. He has an assistant at 20 fl. a month, who once a week carries down the sheets from the self-registering instruments to be mailed to Vienna.

Simultaneous observations of precipitation and temperature used to be made at Schäffleralp, on the Obir, at a height of 1,063 m., and more recently at Schloss Hagenegg, the valley station, 750 m. above the sea. Klagenfurt (438 m.) 25 kil. N. W. is a station of the first order.

Results of Observations.—Hourly values of the pressure and temperature on the Obir for the past five years are now obtainable from the registering instruments and will henceforth be published in the *Jahrbuch der K. K. Central Austalt für Meteorologie.* The observations for 1883, as published in the *Jahrbuch* in the international form, show a mean annual pressure of 594 mm. and a mean temperature of —0.6°, with absolute extremes of 19.2° and —21.0°. The coldest month was March with a temperature of —9.4° and the warmest August with 8.3°. The total precipitation was 1,261 mm. on 133 days, the mean relative humidity 90 per cent. and the mean cloudiness 6.1. Perfectly clear days are more common here in winter than in the valley. From the recent anemometric records Dr. Pernter shows the prevalence of S. E. winds, proving the mountain to be influenced by the Italian region of low pressure, and to be too low to be affected by the continuous upper S. W. current, as is the Sentis. On account of the high humidity and low temperatures in summer, frostwork often forms then. The first snow generally falls

in September, reaching a depth of 5 m. during the winter and disappearing late in June.

That the results of the Obir observations have been thoroughly investigated, the following partial list of the discussions shows. Von Humboldt and others utilized the early observations, as did also Dr. Hann in 1867–68 in his treatise in the *Sitzungsberichte der k. Acad. der Wissenschaften* on the relations of wind direction and temperature, and the decrease of temperature with altitude. Dr. Pernter has made the records of the barograph the basis for a work on the daily and yearly periods of the pressure on mountain tops, and the anemometric diagrams the subject of papers on the wind's period at high altitudes in the Austrian *Zeitschrift für Meteorologie*, and in this journal for July, 1884, will be found a discussion by the same author of the thermograph and sunshine recorder traces. Dr. Pernter devoted a month's residence on the Obir to psychrometer studies and published the results in the *Sitzungsberichte der k. Acad. der Wissenschaften*, for 1883.

Other Austrian Mountain Stations

are the Schafberg and Schmittenhöhe, 1,776 m. and 1,935 m. high, respectively. The Austrian Meteorological Society proposes to establish a meteorological station on the Sonnenblick, 3,100 m., in the Goldberggruppe, near the boundary of Salzburg and Carinthia, which will thus be the highest complete station in Europe. It is intended to fully equip it with registering instruments and to have it ready by July, 1887.

The Sentis

in Lat. 47° 23′ W., Lon. 9° 28′ E., is the loftiest mountain of the Swiss canton of Appenzell, and rises as a rocky peak, far above its neighbors, to a height of 2,504 m. It was the point indicated by the International Meteorological Commission as the most suitable in Switzerland on which to establish a high station, both on account of its isolated position and easy access. The summit is about 11 kil. from the village of Weissbad, which is 3 kil. from the town of Appenzell.

Meteorological Station.—By means of private subscriptions

and a sum granted by the Swiss Central Meteorological office, which had then become a government bureau, Director Billwiller was able to build a telegraph line in the summer of 1882 from the summit of the Sentis to Weissbad at its foot, a work accomplished with difficulty at a cost of 3,400 francs. The line is carried on wooden posts in the valley and upon iron rods set in the rock higher up. In winter, to prevent breakage by ice and frost work, the wire is laid on the snow, as is done with the Obir line, and the snow is found to be a good insolator so long as it is not melting. Telephonic communication is very good over 9 kil. of wire, spanning a difference of altitude of 1,600 m. Owing to the small sum at Director Billwiller's disposal no observatory building could be erected, so the station was established in August, 1882, in the wooden inn erected in 1874 about 40 m. below the summit of the Sentis, by which it is somewhat sheltered on the S. W. Though the room used as a meteorological office is on the first floor of the inn, yet, on account of its light construction, and the crowds of visitors in summer, the instruments are then in a constant state of vibration. It cannot be denied that observations made on the extreme summit would differ materially from those now obtained. The situation of the station is very similar to that on the Wendelstein, since neither is upon the summit. The Sentis, however, has the advantage over the Wendelstein of carrying on its more accessible summit an anemograph, and in this respect more nearly resembles the Hoch Obir.

The finding of an observer was not easy. The first was a post official and the second a school teacher. He receives 2,000 francs a year and board. An arrangement was made with the inn keeper to undertake the lodging and board of the observer and to keep another man with him during the winter. The annual cost of maintaining the station aggregates about 6,500 francs and in the three years since its establishment about 28,000 francs have been expended.

Besides the normal fixed cistern barometer made by Hermann and Pfister of Bern, there is a Hottinger aneroid barograph, both at an elevation of 2,467 m. From a N. W. window projects

a cylindrical zinc screen with a conical ventilated roof and perforated shelves on which are placed the thermometers and the Koppe hair hygrometer. In winter, on account of the drifting snow which covers this screen, the instruments are moved into a louvre screen outside a double window in the second story. The Hottinger thermograph was rendered useless by the frost work which formed on it, and as Director Billwiller considers all metallic thermometers to be sluggish in their action, he has abandoned them and employs instead four of Negretti and Zambra's so-called "turn-over thermometers." This instrument consists of a mercurial thermometer whose tube is contracted and bent near the bulb, so that the mercury column breaks there when the thermometer is inverted, and the temperature at that instant can be read off at any time from the mercury in the tube which is graduated in reverse order. Each thermometer is attached to a clock which can be set to turn it over at any predetermined hour. Here they are set for 4 and 10 A. M., and 4 and 12 P. M., and direct eye observations are made also at 7 and 10 A. M., 1, 4 and 9 P. M. From these two series of observations the mean, maximum and minimum temperatures are obtained. The rain gauge, consisting of a simple zinc cylinder with an area of one-twentieth square meter, stands on a post with its rim 1.50 m. above the surface of a little plateau to the north of the inn and some 10 m. above it. The gauge is read daily at 7 A. M. and the nature, amount and duration of precipitation are noted. A Wild wind vane and pressure plate near by gives the direction of the wind to sixteen points and its force on a scale of four.

The set of complete observations at 7 and 10 A. M., 1, 4 and 9 P. M. comprises reading of the barometer, corrected only for temperature; wet and dry bulb thermometers and hair hygrometer; wind force and direction; state of sky; amount of cloud (0–10) and direction from which moving.

Every morning a cipher dispatch containing the 7 o'clock observations, with those of 7 P. M. of the previous day, and, later, the 1 o'clock observation, is telegraphed to Zürich, there to be used in the preparation of the Daily Weather Bulletin. From here the reports go the Meteorological Offices in Hamburg,

Vienna and Rome, to be included in the daily weather charts and bulletins issued by these offices. The observations made on the Sentis are also published daily in the St. Gallen *Tagblott* and are found to be useful for local predictions of the weather. For instance, the setting in of a fresh West wind on the summit shows more certainly than the observations below, if the weather is to be influenced by the depression advancing from the Southwest, and the sudden rise and fall of the temperature or pressure indicates in advance the presence of a cyclone or anti-cyclone. At the end of the month the register of observations is sent down to the Central Office at Zürich, there to be checked and at the end of the year published in brief, according to the recommendation of the International Congress, in the *Annalen der Schweizerischen Met. Central Anstalt.* Observations at 7 A. M., 1 and 9 P. M. are made at all the Swiss stations. That nearest the Sentis is Trogen, a station of the second order, lying about 24 kil. N. E. of the Sentis and 1591 m. below its summit. These observations are also published in the *Annalen.*

On the highest point of the Sentis at an altitude of 2504 m., stands a Beckley anemograph made by Munro of London, and erected in July, 1883, at a cost of 5,000 francs. This instrument, which is the one used at the stations of the English Meteorological Office, has a set of Robinson cups, 1.30 m. between the centres, and two vane wheels below. The first transmit the velocity, the latter the direction of the wind by means of two shafts one within the other, having ball bearings to reduce friction and universal joints to allow of lateral play, to two horizontal cylinders on one axis. Around these cylinders are raised brass screw threads which record their revolutions on metallic paper passing over a drum beneath turned by a clock. The paper is divided in the direction of its length into hours and quarters and must be changed every three days. It is ruled transversely by tens of kilometers for the velocity of the wind and to eight points of the compass for the direction, and one revolution of the velocity screw corresponds to 50 kilometers of travel and one turn of the direction screw to a change of the wind through a complete circle. This part of the apparatus is inclosed in a

hexagonal pyramid, having a platform on top from which the cups and vanes some 5 m. above the ground are accessible. The structure is built around a strongly braced iron tripod, 4 m. high, which was erected for a trigonometrical signal. Special pains were taken to protect the anemograph from lightning, as it was known that the peak was subject to violent electrical discharges. The iron railing surrounding the platform before mentioned, has six lightning rods connected with copper cables which are burried in the rock below. On account of the frost-work which collects very rapidly on the cups and vanes whenever the moist West wind blows and the temperature is below freezing, it has been found impossible to maintain the instrument working during the whole year. Thus, from September, 1883, to August, 1884, there were only 142 days when the anemometer registered. At the time of the writer's visit in August last, though the minimum temperature was only —2.3°, frost-work formed in one night to a length of 15 c.m. and brought the anemometer cups and vanes to a standstill, making it necessary to break off the incrusted ice in order to free them. In winter, during severe storms, the observer sometimes finds it impossible to climb to the summit for this purpose or to renew the paper and wind the clock.

Proposed Observatory. For this reason and those before stated, it would seem to be very desirable to build an observatory on the extreme summit, and the following plan, which was approved by Director Billwiller and the other eminent meteorologists who together with the author visited the Sentis by his invitation, was proposed by Dr. Assmann. The idea is to excavate the small rocky plateau forming the summit and to have a glass roof projecting but little above the ground. This is to be connected with the anemometer hut by a covered gallery and besides the room of the observer, the building would contain apartments for scientists who wish to make investigations here. There should be self registering apparatus for all the elements, including atmospheric electricity and earth magnetism. A heated rain gauge and anemometer are suggested to avoid clogging by frost-work. The execution of such a project in the near future

is the more probable since the State has now assumed the maintenance of the Sentis station, and a sum of money will probably be put at Director Billwiller's disposal for its improvement. A letter from the latter gentleman, however, states that the observatory will not be built this year, but that, as the inn is to be enlarged, more commodious quarters will be obtained there.

Results of Observations.—As before stated the observations appear annually in the *Annalen der Schweizerischen Met. Central Anstalt.* The means from September, 1882, to August, 1884, are given by Director Billwiller in his brochure *Bericht über die Errichtung der Met. Station auf dem Säntis und ihre Thätigkeit,* and an interesting work on the daily variation of the pressure on the Sentis as compared with the Great St. Bernard has been published by Dr. Maurer in the Austrian *Zeitschrift* for December, 1884. This diurnal period is interesting. The barometer reaches its chief maximum about 10 P. M., and a minimum about 5 A. M., while during the day it remains about at its mean height, a phenomenon which has lately been shown to occur at other high stations. Since the establishment of the anemometer the inversion of the wind's diurnal period, as compared with low levels, is very plainly demonstrated, the difference between the minimum velocity, occurring before noon, and the maximum velocity about midnight amounting, sometimes, to one-third of the maximum velocity. The data for the month of August, 1883, have been discussed by Billwiller in the Austrian *Zeitschrift* for November, 1883, and an article by the same author embodying the latest observations, both here and elsewhere has just appeared in the December number of the above journal. The following summary of the Sentis observations is for 1883. The mean barometer was 564 mm. with a range of 33 mm. The mean temperature was —2.4° with an absolute maximum of 14.9° in July, and an absolute minimum of —22.4° in March. The coldest month was March with a mean temperature of —10.1°, the warmest August with 4.7°.

The precipitation was 1,696 mm. which fell on 192 days. The mean relative humidity was 84 per cent. and the mean cloudiness 6.4. During January, 1884, the anemometer registered a total

movement of 24,863 kil., the mean velocity being 33.4 kil. per hour, and the maximum 111 kil. an hour. The preponderance of S. W. winds shows the peak to be high enough, unlike the Obir, to be influenced by the upper S. W. current.

The Rigi and Other Swiss Stations.

The station on the well-known Rigi-Kulm in Lat. 47° 3′ N. and Lon. 8° 30′ E., 1,790 m. above the sea, is of the second order and has the instruments ordinarily used at such Swiss stations, the observations being made tri-daily. The station is established in one of the large hotels and did not seem to be well managed by the telegraph operator who receives only 50 francs extra for his trouble during the summer. The 7 A. M. and 1 P. M. observations are telegraphed then to Zurich for publication that afternoon in the Daily Weather Bulletin. In winter the observations are made by the hotel watchman. At the end of the month the original record of observations goes to the Central Bureau, there to be reduced and the means calculated, they being afterwards published for the year in the *Annalen.* Those for 1883 show a mean pressure of 615 mm., a mean temperature of 1.33°, with extremes of 19.8° and —18°, and a total precipitation of 1,692 mm. The situation would seem to be admirable for a first class station, and it would be possible to have a corresponding low-level station some 1,000 m. below at the foot of the steep Northern side of the Rigi.

Another high station is the Great St. Bernard, one of the oldest, situated in the hospice of that name, at a height of 2,478 m. Observations, formerly made every three hours, are now taken tri-daily, but owing to the situation in the pass, they are much less valuable than if made on a free-lying peak. There is a similar station at the St. Gotthard hospice (2,100 m.) and another, which is the highest in Europe, in the Theodule pass (3,330 m.) This latter, therefore, exceeds in height the Sentis by more than twice as much as the Sentis overtops the Obir. A recent attempt to place registering instruments on the summit of the Faulhorn (2,673 m.) was unsuccessful.

[TO BE CONTINUED.]

OBSERVATIONS ON THE SUN-GLOW AND RELATED PHENOMENA*

In November, 1883, at the time the fire-red after-glows were attracting so much attention, I discovered the ruddy glow around the sun. Since that time I have observed the phenomenon every day, that is, enough to determine its presence or absence, and, if present, its intensity, tint, etc. It seems to be necessary that these semi-personal matters be given in order that the Association may know the circumstances under which the observations here recorded were made.

The phenomena have often been described, but I will put them on record just as I have observed them. It should be added that at this elevation there are better facilities for observations of this kind than at sea-level. My first written account of them was published in *Nature* in March, 1884. For about 10° from the sun the sky is very bright and white, then comes a broad, colored ring extending from about 10° to about 30° from the sun. I have never measured the angular distance with an instrument, but one cold morning in January, 1884, I chanced to see a pair of very bright "sun-dogs" at the upper edge of a massive cloud which hung low near the Eastern horizon. The sun appeared at the upper edge of the cloud and the reddish glow formed a beautiful arch above it. The sky was very clear above the cloud and thus was given a good chance to observe.

1. The halo appeared a little outside of the center of the reddish zone.

2. The color extended a little more than half way from the halo to the sun.

3. Near the halo the color of the ring was most intense, and became fainter toward each margin.

As this was the normal or primary halo, the dimensions of the chromatic zone must be given as above. I have observed a variability as to the part of the ring showing the deepest color.

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* Paper presented at the first annual meeting of the Colorado Meteorological Association, by Prof. George H. Stone, of Colorado College.

Sometimes the part of greatest intensity is nearer the inner margin of the ring.

VARIATIONS IN COLOR.

There has been considerable variation in the color of the glow. In November and December, 1883, it had a distinct tinge of yellow or orange. In this connection I may add that my eyes were once tested and that they were found to be free from color blindness proper, and quite sensitive to even small differences in shade. In a matter where one can so easily be mistaken, I did not trust my own eyes fully, but repeatedly pointed out the ring to others and asked them what the color was. All agreed that the color in November and December, 1883, showed an orange mixture, while by April, 1884, it had become pinkish or reddish-brown. This may have been caused by the midday sky tints, then well developed as shown elsewhere. During the summer of 1884 it diminished in intensity and remained reddish-brown. In the autumn of 1884 the orange appeared again, but less marked than the preceding year; also during the cold season it was more intense than during the summer preceding. Toward the spring of 1884 it became dull reddish-brown and has continued about that color ever since. The glow was least intense during July and August both of 1884 and 1885. It was most intense during November and December, 1883 and 1884. During November and December, 1885, the glow has only appeared a few times, and then not as intense as at the same time in 1883 and 1884. In a word, the glow was deeper in color and appeared more constantly in 1883 and 1884 than since. Occasionally the glow is of a brighter red for a few hours, sometimes almost a coppery red, especially when the sun is near the edge of a cloud.

VARIATIONS IN INTENSITY.

The variations in tint just named seem to depend upon the seasons and a general decrease in the intensity of the forces producing the glow. Besides these there were marked variations in the intensity of color from day to day. For one and one-half years after November, 1883, the glow was present most

of the time, and at first without very great variation from day to day. As time went on these temporary variations became more marked, and during 1885 the glow was always fainter than in 1883, and during the last months of the year often was absent for some days, and even several weeks at a time. Early in 1884 I began to notice a relationship between the sun-glow and temperature. Any marked increase in the intensity of the tint was invariably followed by a fall in temperature. I soon discovered that the glow also grew more intense before a cold storm. Thus, in February, 1884, after several days of zero weather with some snow, it cleared off cold and cloudless. The sun-glow was entirely absent during the forenoon. About 3 P. M. the glow had become a magnificent display of color, and the upper air seemed filled with a very faint structureless haze. By 9 P. M. the sky was overcast with clouds, and during the night there was a severe snow-storm on the Divide and a light fall at Colorado Springs. During the spring of 1884 the same thing was repeated many times. Snow-storms and hail-storms were preceded and accompanied by an increase in the intensity of the circumsolar glow, while rain-storms showed little—usually no perceptible increase. Whenever there was much vertical movement of the air in a squall or storm, as shown by the formation of round-topped cumulus clouds, their great height, intense lightning, etc., there was always a deep tint of the sun-glow. In a word, a deepening of the tint preceded and accompanied the precipitation and moisture at a rather low temperature, as shown by the formation of snow or hail, and by the fall of temperature at the surface of the earth which invariably followed.

I spent July and August, 1884, in Maine, and twice saw the ruddy sun-glow in marked intensity. Both times its appearance was followed by violent electrical storms and local areas of hail. I also spent June, July and August, 1885, in Maine. The glow appeared several times, accompanying and following cold electrical storms for two or three days, and then disappearing. I did not during 1885 discover in Maine the glow at any time appearing *before* the storm, but when it was seen near the edge of a distant storm-cloud the storm invariably turned out to be a

cold one, hail being reported in various parts, while Mount Washington came out of the storm white with hail or snow, and the general temperature fell many degrees. At Colorado Springs, whenever there is precipitation from low stratus clouds there is less increase in the intensity of the glow than when the moisture reaches to a great elevation in the air.

Since last August the sun-glow at Colorado Springs has been rather inconspicuous. In November it was absent most of the time. During December it was absent for several weeks, although there was in that time a light fall of snow and a temperature of 5° below zero.

On the morning of December 30 it suddenly blazed out with considerable intensity. About 8:30 A. M. I looked up at a cloud nearly overhead in order to determine the direction of the wind. The cloud was nearly round, and covered not far from 45° of arc. A glance showed clouds moving rapidly from the southeast. A little later I saw that the clouds near the mountains must come from the west. I then looked up at the cloud first observed. There it was in the same position, and yet the cloud was moving from the northwest. These observations seemed so contradictory that I began to observe the cloud carefully. Near the center of the cloud was an area with a diameter about one-third as great as the cloud, where small cloud masses ending in short streamers seemed to be in confused motion among themselves; but it was a small motion, only enough, by their overlapping, to cause a rapid change in the apparent shapes of the cloud masses. From the outer edge of this central and nearly stationary mass of cloud small cloud masses shot rapidly outward in all directions, their movement becoming slower as they receded from the center, but not entirely ceasing, even up to the edge of the cloud. I looked at this cloud at short intervals for about ten minutes, when this and numerous scattered clouds suddenly disappeared. All of these small clouds showed a confused rolling movement, and one showed a radiating movement, but not so plainly as the one in the zenith. At this time the barometer was low and Pike's Peak had hung out a cloud banner. The divergent movement in the stationary cloud was perfectly distinct. I examined it a dozen

or more times, and cannot be mistaken regarding it. There was evidently here either a central column of moist air ascending into a colder and drier stratum, or vice versa. Here, then, were two strata of air in a state of unstable equilibrium. Wherever they became mixed at local vortices distinct cloud masses were formed. But two such strata cannot be in contact without some diffusion and mixing near the surface of junction. This mixing must under the conditions cause precipitation. But if the mixing be quiet the ice or water particles would be too few to form more than so tenuate a cloud that we would not recognize it as a cloud at all, but only as a faint structureless haze. I think the facts here recorded show that the conditions were such that there must have been such a diffused cloud of ice or water particles near the line of junction of the upper and lower strata the morning of December 30. That they were ice and not water particles is rendered probable by the fall of temperature which followed. If these inferences be well founded, then diffraction from the particles of the haze-cloud may explain the sun-glow of that morning. I will add that by noon of December 30, it was snowing at Colorado Springs; by 3 P. M. it had partially cleared away and the brown sun-glow was so bright that the clouds to the E., S. E. and N. E., were tinted the same color. Soon it began snowing again and we had the severest storm of the season.

[The above was written Jan. 1, 1886. The subsequent history is as follows. The storm of Dec. 30 continued for several days, and the thermometer fell almost to zero. At length it cleared away and the morning of Jan. 3 was absolutely cloudless, yet the sun-glow was quite intense all the forenoon. Near noon it began snowing on the mountains and for a time it threatened a general storm, but before night the clouds had disappeared and an equilibrium had apparently been attained. Jan. 4 was nearly cloudless and not a trace of the sun-glow could I see at any time, though I examined the sky every hour or two throughout the day. On Jan. 5 the glow re-appeared and kept increasing in intensity during that day and the next. By noon of Jan. 6 the glow had become not only extraordinarily intense, but almost coppery in tint. At that time I remarked to several persons

that according to the past history of the sun-glow there must be a violent cold storm impending. On this occasion as on many others the glow turned out to be a correct prognostic. The great storm of Jan. 7–10 was heralded by a sun-glow whose lurid intensity was worthy of one of the worst Northers ever experienced on the great plains. Indeed the people of the whole region east of the Rockies, from the great lakes to the Gulf, will not soon forget that storm. Since then we have had (up to Jan. 28) three storms with slight precipitation at this place. The sun-glow has been absent most of the time. On a few occasions it has appeared rather faintly near morning and night, disappearing during the middle of the day. In such cases I am not sure whether this is always the true sun-glow or something else. I have compared my observations relating to the last month with the cloud and temperature records of Prof. F. H. Loud of Colorado College.]

IRIDESCENT HALOS.

During every winter iridescent halos are seen at this place, generally through the thickening haze or thin cloud which appears just before a snow storm. Sometimes all the colors of the rainbow have been seen simultaneously, but more often the colors at the red end of the spectrum appears, the blue and violet being wanting. A few times the halos have been variegated, red appearing at one part of the arc, and yellow at another part not far away, separated sometimes by a neutral tract. Once a small green patch appeared in the midst of a yellow arc of about 90°. Like white halos these iridescent ones may be complete circles, or only fractions of circles. The breadth of the iridescent halo appears to be greater than that of the white halo, perhaps because the border is often not so clearly defined. Twice near night I have seen iridescent halos when the sun appeared not far above the Pike's Peak range of mountains. The base of these mountains is about four miles westward from this city and they rise from 6,000 to 8,000 feet above us. On both these occasions the iridescence did not stop at the top of the mountains, but extended to the plain at the base of the foot hills. In other words the iridescent halo appeared between us and the moun-

tains. The mountains were thinly veiled by what appeared to be a haze and could be seen directly through the halo. On both occasions the temperature of this place was at the time 15° to 20° below the freezing point, and it must have been as cold or colder on the mountains.

[TO BE CONTINUED.]

CORRESPONDENCE.

ELECTRICITY AND TORNADOES.

To THE EDITOR:—I read, yesterday, a copy of your journal (September number), from a friend of yours. It was the first I had seen, and I was much interested in its contents, especially the article on "Tornado Generation." Several years ago, a tornado passed near this place, which gave me an opportunity to pass over its path of destruction, and I saw some things from which I believed then, as I do yet, that there was some other force besides the wind which put in motion the objects in its way.

The tornado was preceded by a dark cloud from which there was considerable thunder and lightning, but there was very little, if any, near the tornado. After the storm had passed, the air was saturated with ozone to such a degree that even the small children noticed it, who compared it to the odor of burning brimstone or burning matches. Unfortunately, I once stood a few rods from a tree when it was struck by lightning,and I distinctly remember the peculiar odor which I attributed to ozone which had been formed by the passage of lightning through the air. As the odor which followed or accompanied the the tornado was similar, I concluded there must have been electricity with it. I followed the path of destruction, which was not over ten rods wide, for a couple of miles, and at different places saw small hickory and white oak trees, from one to two inches in diameter, ruptured or burst open, with crevices on all sides as though they had been exploded with some explosive; the fine splinters standing out, brush-fashion, on all sides. These small trees grew on ground which

had once been farmed, and were of slow growth and the toughest which grow. There was such a marked difference between these, and those which had been twisted by the wind, that I had no difficulty in distinguishing one from the other. They were ruptured by electricity. At other places I saw small roots which had been laid bare, split open without any other marks about them, and I believed them to have been split by electricity. Had they been split by any visible or hard object, it must have left some other marks upon them. This, again, must have been the work of electricity.

The above evidences of the force and other signs of electricity in tornadoes I have seen, while I have read and heard of many others. In an adjoining county, two years ago, a little village was almost totally destroyed by a tornado and several lives lost. Some of the killed were found to be terribly burned, while all who saw the tornado declare they saw the fire descend from the clouds. All the evidence points to electricity as the origin of the fire. Persons who have been carried from the ground in one of these storms, experienced a prickly sensation all over the body, which must be attributed to electricity.

Yours, very truly, H. D. MOORE, M. D.

NEW LEXINGTON,
Somerset Co., Pa., Jan. 8, 1886.

THE DIRECTION OF WHIRLS.

TO THE EDITOR:—In your valuable Journal I read with interest the remarks of Mr. Faye about whirls and find the same appropriate; but I do not find recorded the observation "That all whirls by wind and water turn from the right to the left," or it is said, "against the sun." I have observed the same hundreds of times in nature and experiment, and never find it the other way.

It is a law of nature that all bodies which revolve, go from the right to the left. It is so with our planets according to our astronomers, "from the west to the east;" it is so with our plants which wind, most all of them—the hop plant is one—wind from the right to the left or against the sun.

If two turbines work under the same circumstances, one with, the other against the sun, the latter has more power than the first; all millstones, all parts of machinery which run horizontally, work the best from right to the left. By all these observations--and more than I can mention—I find this law: the human race have one and the same hand for the right; also about meteorological observations, the same law plays a great role; for instance: by S. W. wind, thunder-clouds may every time first be seen in the N. W.; also, the tradewind comes from the N. E. and the anti-trade from the S. E.

Respectfully yours, M. MEINHARD.

TROY GROVE, ILL., Jan. 13, 1886.

DEEP-SEA TEMPERATURES.

TO THE EDITOR:

Referring to the discussions contained in your October number, upon the supposed increase of temperature with the increase of depth below the earth's surface, I beg that you will permit me to call attention to the results of all deep-sea soundings, in which temperatures of the oceans have been taken at from two to five miles below the surface and directly in contact with the bottom of the seas. In every case, I believe, the deep-sea thermometers have registered temperatures of from 28° to 32° Fahrenheit (or below the freezing-point of fresh water) whenever the soundings have reached below the surface currents of the ocean.

If the centre of the earth is a ball of fire or incandescent, then these great depths, which have been reached by the sounding-lead, have carried the thermometer so much nearer that centre heat of the earth than any mines or wells have ever reached, that a corresponding temperature ought to be shown, but just the contrary has been the case in every recorded instance.

Having no faith whatever in the theory, I should be greatly surprised if any experimental borings into the earth could ever afford reliable testimony in its favor.

Very respectfully yours, SILAS BENT.

ST. LOUIS, Nov. 16, 1885.

LITERARY NOTES.

(209) **Rudolph Spitaler.** *The Distribution of Temperature over the Earth's Surface.* [Die Wärme-Vertheilung auf der Erdoberfläche, von Rudolph Spitaler, Assistent an der K. K. Universtäts Sternwarte zu Wien.] Reprint from Vol. LI. of the Denkschriften der mathematische-naturwissenschaftlichen Classe der kaiserlichen Academie der Wissenschaft.

The foundation for the author's researches on this subject was laid in the isothermal charts of Wild for Northern Asia and Eastern Europe in "Die Temperatureverhältnisse des Russischen Reiches," and of Prof. Hann in the new edition of Berghaus' Physical Atlas. Following the example of Dove, and others, the author proceeded with these recent and most nearly perfect charts, to obtain: 1°, the temperatures for each tenth degree of latitude and each fifth degree of longitude around the globe, and for the intermediate latitudes of 5° intervals the temperatures for each tenth degree of longitude only, all of which he has given in a very large table; 2°, the normal temperatures of latitude by taking the averages of these equi-distant values around the globe for the several parallels of latitude. This was done for the mean of the year, and of January and July. The normal temperatures of latitude thus obtained are given in the following table:

LATITUDE.	NORTHERN HEMISPHERE.			SOUTHERN HEMISPHERE.		
	Year.	Jan.	July.	*Year.*	Jan.	July.
90°	— 20°.0	— 36°.9	2°.0	9°.3†	....	....
80	16.5	32.0	2.6	8.4†	....	....
75	13.3	29.1	4.0	....	....	....
70	9.9	25.5	7.3	4.9†	....	....
65	4.3	22.5	12.2	....	....	....
60	— 0.8	16.0	14.1	0.2	....	....
55	+ 2.3	10.9	15 7	3.2	4.6	— 0.6
50	5.6	7.2	18.1	5.9	8.1	+ 3.2
45	9.6	— 2.3	20.8	8.9	12.5	6.7
40	14.0	+ 3.9	23.8	11.8	16.1	9.7
35	17.1	8.8	25.8	15.2	19.3	12.4
30	20.3	13 9	27.4	18.5	22.6	15.3
25	23.7	18.4	28.0	20.9	24.7	18.1
20	25.6	21.7	28.1	22.7	25.5	20.5
15	26.3	23.9	27.9	24.2	25.7	22.6
10	26 4	25.7	26.7	25.0	25.9	24.0
5	26.1	26.2	26.1	25.5	26.1	24.9
0	25.9	26.2	25.5	25.9	26.2	25.5

With regard to these results the author remarks: "A comparison between the mean yearly temperatures of the northern and southern hemispheres shows that from the equator to the parallel of 45° the

hemisphere is warmer than the southern; this difference reaches its maximum 2.9 and 2.8° on the parallels of 20 and 25°. Beyond the parallels of 45° the relations become reversed, and the southern hemisphere becomes warmer than the northern; and indeed this is the case in so great a degree that in the highest latitudes the difference amounts to nearly 10°, if the temperatures obtained by Dr. Hann for high latitudes should have much weight." The latter are the three temperatures in the preceding table indicated by †. Of course there is considerable uncertainty with regard to these, since they are necessarily based upon very few observations, and none of these very near the pole. He likewise remarks that "the warmest parallel is not on the equator, but that of 10° N. with a temperature excess of 0.5° over that at the equator. Many other relations are pointed out which will be readily seen by the reader for himself from an inspection of the preceding table.

The normal temperatures of latitude for the northern hemisphere differ but little from those obtained by the writer* from Buchan's isothermal charts, the differences rarely amounting to one degree; but in the higher latitudes of the southern hemisphere the differences are considerably greater, the normal temperatures of latitude being generally lower. The values given in the preceding table are, undoubtedly, the more correct of the two sets.

With the results in the preceding table the author, after the manner of Prof. Forbes, determines the numerical constants in the following general formula for representing the normals of latitude for the mean of the year:

(1) $T_{\Phi} = -2.43 + 17.61 \cos \Phi + 7.05 \cos 2\Phi + 19.29\, n \cos 2\Phi$, in which Φ is the latitude, and n the ratio between the part of the parallel occupied by land and the whole parallel. This is different from the form adopted by Forbes, having an additional term in it. This formula represents the author's normals very satisfactorily in both hemispheres, using Dove's values of n.

Putting $n = 0$ in the expression above, it becomes that of a water hemisphere; but with $n = 1$, that of a land hemisphere. In the former case it becomes

(2) $T_{\Phi} = -2.43 + 17.61 \cos \Phi + 7.05 \cos 2\Phi$,

and in the latter

(3) $T_{\Phi} = -2.53 + 17.61 \cos \Phi + 26.34 \cos 2\Phi$.

Multiplying by $\cos \Phi\, d\Phi$, since each parallel has weight in proportion to the circumference of its circle, and so proportional to the cosine of its latitude, and integrating from $\Phi = 0$ to $\Phi = 90°$, there is obtained

* Meteorological Researches, Part I, Coast Survey Report for 1875; Appendix, No. 20.

$$(4) \int_0^{90} (A + B\cos\Phi + C\cos 2\Phi)\cos\Phi \, d\Phi = A + \frac{B\pi}{4} + \frac{C}{3}$$

in which

$$\begin{aligned} A &= -\ 2.43. \\ B &= 17.61. \\ C' &= 7.05 \text{ (for a water hemisphere).} \\ C'' &= 26.34 \text{ (for a land hemisphere).} \end{aligned}$$

The preceding integral gives 13.8° as the mean temperature of a water hemisphere, and 20.2° as that of a land hemisphere.

The author remarks, however, and very justly, that it would be very erroneous to conclude from these results that the southern hemisphere, which is very nearly a water hemisphere, must be colder than the northern hemisphere, which has a much greater proportion of land. In fact the preceding mean temperatures would be those of a wholly land and a wholly water hemisphere, upon the hypothesis only that the winds do not tend to equalize the temperatures of land and water surfaces, an effect which was not taken into account by Forbes. If we had a narrow strip of land extending between two oceans from the equator to the pole, its temperature in all latitudes would differ but little from that of the oceans on each side; and, commonly, a narrow ocean extending from the pole between the two continents, would have, on each parallel, very nearly the same temperature as the land. The land and ocean temperatures, therefore, are not independent of each other.

In the preceding formula (1) the value of n is given by Dove for each fifth degree of latitude only; and if it were known for all parts of the intermediate spaces, it could not be expressed in such a formation of φ as to make the expression deduced from (1) in the same manner that (4) has been deduced from (2) or (3), integrable. The author, therefore, has resorted to a mechanical integration, by determining the product of each zone of five degrees in width into its area, and thus adding these and dividing by the whole area of the hemisphere.

As the value of n is not known near the poles, it leaves some uncertainty with regard to the regions immediately surrounding the poles. Assuming that the part of the northern hemisphere between the parallel of 75° and the pole is water, free from ice, the author gets 15.3° for the mean temperature of the northern hemisphere; but upon the supposition that it is all land, he gets 14.7°. In like manner, in the southern hemisphere, if the part between the parallel of 65° and the pole is open sea, free from ice, he gets for the mean temperature of the hemisphere 15.7°; but, if it is all land, 14.2°; and so for both hemispheres very nearly the same value, which, upon the hypothesis of an equal distribution of land and water in the polar seas, would make the mean temperature of each hemisphere equal to 15.0°, which, the author thinks, agrees very

well with the results of others, of which he gives the following synopsis: For the northern hemisphere, Dove, 15.5°, Schoch, 15.1°, Ferrel, 15.3°; for the southern, Sartorius von Waltershausen, 15.8°, Schoch, 14.9°, Ferrel, 16.0°, Hann, 15.4° and 15.2°.

For the zone of the northern hemisphere from the equator to the parallel of 45° the author finds a mean temperature of 22.1°, while for the corresponding zone of the southern hemisphere it is only 21.0°; and so there is a difference of 1.1°.

By methods very nearly the same as in the preceding case, the author obtains for the yearly mean temperatures of the two hemispheres in January and July the following results:

	January.	*July.*
Northern hemisphere	7.97°	22.54°
Southern hemisphere	17.54	12.35
The whole earth	12.8	17.4

Dividing the earth into two hemispheres with the meridian 80° W. and 100 E., the eastern hemisphere, 80° W — 100 E., is mostly land, and the other mostly water, and he finds for the mean yearly temperature:

	East Hemisphere.	*West Hemisphere.*
North	16.7°	13.9°
South	14.3	14.9
The earth	15.5	14.4

For January and July of the northern hemisphere:

	January.	*July.*
Eastern hemisphere	9.4°	23.6
Western hemisphere	6.5	21.5

The eastern hemisphere, therefore, for the yearly mean is about 1.1° warmer than the western one. While for the yearly mean in the southern hemisphere the mean temperature of both halves is nearly the same, the difference being only 0.6°; in the northern hemisphere it is 2.8°.

The author has done a good work for the temperature of the globe, All the recent observations of barometric pressure made over the great oceans could now be made available in drawing isobars, with some approximation, at least, to accuracy in nearly all parts, and then with these a similar work should be done for the atmospheric pressure of the globe. But perhaps it could hardly be expected that all this could be undertaken as a private work, and if so, it should be done by some meteorological office or bureau. Wm. Ferrel.

(210) **L. Sohncke** *on the Origin of Thunder-storm Electricity.* pp. 406–7 An extract from "Sitzungsberichte der Jenaischen Gelleschaft für Medecin und Naturwissenschaft," Jahrg, 1885.

Prof. Sohncke gives the results obtained during a number of balloon ascents to show that during thunder-storms the temperature of freezing in the upper air approaches nearer the earth's surface than during ordinary summer weather; he gives reasons for believing that both water

and ice particles exist in the upper part of thunder-clouds; and concludes that thunder-storm electricity is caused by the friction of the two.

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(211) **Kiessling.** *Ueber die Entstehung des zweiten Purpurlichtes und die Abhängigkeit der Dämmerung's Farben von Druck, Temperatur und Feuchtigkeit der Luft.* As to the cause of the remarkable red twilights observed for several years past, the author believes that but two hypotheses are tenable. Either the illumination is due to the reflection of the diffracted solar rays, or the diffracted light has suffered no reflection. The second hypothesis is held to be improbable on account of the great height which must be assigned to the diffracting medium in order to produce the observed effects. A serious objection to the first hypothesis is to be found in the fact that an examination of the light has failed to show signs of polarization to any marked degree. It is true that observations of this character are almost wholly wanting, still such as have been made, and among these are those of the author himself, have in the main, given negative results. This hypothesis also requires the presence of a good reflecting surface. The author then describes the following experimental way of producing, on a small scale, the observed phenomena. On a large glass globe, filled with saturated air, is placed a tin vessel containing hot water, the bottom of the vessel being concave. If at the end of five minutes the upper part of the globe has become sufficiently heated, then by partially exhausting the air an intense but not homogeneous fog will be formed inside of the sphere. The upper portion of the fog is soon dispelled leaving a perfectly clear space directly above a silvery horizontal surface composed of extremely minute globules of water. If a horizontal beam of direct sunlight be now allowed to strike this surface the most brilliant diffraction colors become visible. At a depth of one-half centimetre below the surface, where the fog is no longer homogeneous these colors are entirely wanting. The author assumes that at a certain height above the earth's surface the relative humidity of the air is constantly near 100%, and that at certain altitudes there exist strata of air which are of a higher temperature than strata nearer the earth. The optical effect of this arrangement upon the rays of the setting or rising sun will vary with the difference in temperature, and amount of material present for producing condensation. After the direct solar rays have been diffracted by the lower surface of a high fog (the diffracted ray making an angle of from 15° to 20° with the original direction of the ray) they enter the clear space directly below the fog until they again strike and, under favorable circumstances, are reflected from this lower surface to the earth. From a discussion of observations made in various parts of Europe it appears that at those times when the barometer was highest the displays were most brilliant. There seems to be but little doubt that in some way the Krakatoa eruption originated the remarkable red sunsets. S.